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THE INTERSECTION OF TECHNOLOGY AND EDUCATION: DEVELOPMENT OF DIGITAL GAMING FOR ENHANCED ADDITIONAL MATHEMATICS

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Abstract:

In recent years, Education 4.0 has brought about a revolution in the field of education. By innovative teaching methods, such as gamification and game-based learning, the learning experience has been taken to a whole new level. Among these methods, gamification has emerged as an up-and-coming technique for enhancing students' engagement and motivation in various subject areas. Gamification involves incorporating game-like elements, such as point systems, rewards, and challenges, into the learning process. By leveraging the principles of game design, educators can create engaging and immersive learning experiences that help students develop a deeper

understanding of the subject matter and ultimately succeed in their studies. However, implementing the gamification method effectively and efficiently for specific subjects requires careful consideration and exploration, especially in the subject of Additional Mathematics. This subject has long been acknowledged as one of the most challenging subjects in Kurikulum Standard Sekolah Menengah (KSSM). Students must devote significant time and effort to mastering the subject matter. Therefore, this research focuses on developing an educational game that leverages the Scratch platform to enhance students' learning experience. Specifically, the game will focus on Functions, a crucial topic in Additional Mathematics. The research design involves two main stages. The first stage involves creating comprehensive notes and designing multilevel questions based on credible sources. In the second stage, an immersive learning game will be developed using the Scratch platform using the features in Scratch. The findings of this research indicate that the combination of gamification, detailed note-taking, and a variety of games is an effective tool in connecting the gap between conventional teaching methods and contemporary learning preferences. This innovative approach can transform the traditional education system by making learning more engaging and effective for students of all ages.

Keywords:

Digital Game, Additional Mathematics, Scratch, Secondary School, Educational Game, Gamification

Introduction

The Fourth Industrial Revolution (IR 4.0) is characterised by the integration of advanced technologies such as artificial intelligence, the Internet of Things, big data, robotics, and blockchain into various industries (Saleh et al., 2022; Tzavaras & Karamanoli, 2023). These technologies can potentially transform how we live, work, and learn. Technological advancements have revolutionised the field of education, opening new opportunities for improved learning experiences. Education 4.0 reflects Industry 4.0, a term used to describe the adoption of these cutting-edge technologies in education, revolutionising the way of teaching and learning. Technology's assistance has made the relationship between teachers and students more flexible and widespread. Consequently, technologically driven mediating systems have become indispensable to the classroom-student dynamic (Leonam et al., 2023).

Active learning is essential to attaining the objective of Education 4.0, which is to establish interactive and meaningful learning experiences. By adopting this approach, the students are immersed in the educational journey, enabling them to cultivate practical knowledge and enhance their critical thinking capabilities. Active learning involves students in the learning process through engagement activities and discussions. Studies have shown that active learning strategies are linked with notable improvements in student performance across various STEM (Science, Technology, Engineering, and Mathematics) disciplines (Freeman et al.,2014).

Educational institutions can create a more engaging and productive learning environment by integrating gamification elements in board or digital games. These elements in the game not only make learning fun but also motivate students to participate and perform better. Visualisation of the game helps students visualise their progress and compete with their peers, while points and badges serve as incentives for completing tasks and achieving milestones

(Hellín et al.,2023). By incorporating these game-like features into education, students are more likely to stay motivated and engaged, leading to a more successful learning experience. This approach combines gamification and active learning to boost student engagement and create a more immersive and enjoyable learning experience (Hamari et al., 2015; Keser & Semerci, 2019; Syafrinal et al., 2022).

Literature Review

Additional Mathematics Subject
The Malaysia KSSM Syllabus, or Kurikulum Standard Sekolah Menengah, is the national curriculum for secondary schools in Malaysia (Bahagian Pembangunan Kurikulum, 2018). Additional Mathematics is an elective subject offered to students in Malaysia in Form 4 and Form 5 (Grade 10 and Grade 11). It is a challenging subject that covers a wide range of mathematical topics, including algebra, geometry, calculus, trigonometry, and statistics. The KSSM Additional Mathematics syllabus aims to enhance proficiency in algebra, geometry, calculus, trigonometry, and statistics. It also seeks to reinforce mathematical process skills, encourage critical and creative thinking, and encourage the ability to draw reasonable inferences and make generalisations in diverse situations and conditions. The syllabus additionally aims to equip students with the necessary skills and knowledge to pursue advanced studies and professional opportunities in science, technology, engineering, and mathematics (STEM). In Suzanne (2015), the Functions topic is highlighted as a critical element that enables individuals to acquire a deeper understanding and expertise in tackling real-world problems. Function can be defined as the ability to understand the purpose and usefulness of something or how it works in a given context. This concept is regarded as a fundamental requirement in various fields of study, such as engineering, medicine, and computer science, where it is crucial to comprehend the functionality of systems and devices to enhance their performance and resolve issues effectively. However, it can be challenging for students to comprehend the subject matter because of the formal definition of the function concept (Hoon et al.,2018).

Education 4.0
There are four phases of education, starting with Education 1.0, which was characterised by limited teaching methods available only to a select few, often influenced by religious beliefs. Over time, the education system has significantly transformed from Education 1.0 to Education 2.0. The latter emphasises development and is now the primary responsibility of the state. This change has resulted in a surge in enrollment across all age groups and sections of society. The introduction of printing presses and the establishment of universities have been instrumental in universalising higher education, paving the way for its formalisation. As a result, it has become more accessible to people from all walks of life. Massification has undoubtedly resulted in the teacher being the exclusive provider of knowledge, leaving the student in a passive role as a mere recipient. The concept of education has evolved, where Education 3.0 involved using computers and the internet to aid in teaching and learning, which helped increase access and level the playing field (Sachin & Manjinder, 2023).

Education 4.0, high-speed internet, mobile technology, and social media platforms have enabled personalised learning anytime and anywhere. This has resulted in a role change for teachers, from mere instructors to facilitators and mentors. Education 4.0 empowers learners to take charge of their learning paths and structure them to suit their needs (Sachin & Manjinder, 2023). The contemporary educational landscape is experiencing a paradigm shift

with the advent of Education 4.0. This new paradigm is predicated on applying relevant and cutting-edge skills, necessitating the unlearning and relearning of individuals to improve and requalify them. To meet the demands of this shift, educational systems must adapt to provide students with the skills imperative for building a more egalitarian and productive society. Schools must impart students with both hard skills, such as technology design and resource management, and soft skills, such as communication, empathy, and social awareness. These skills will empower students to shape inclusive and equitable societies for all (Aristin et al., 2020; Winks et al., 2020; Katyeudo & Ricardo, 2022). Figure 1 illustrates the relevant concepts of the higher education transition from Education 1.0 to the current industrial and educational paradigm of Education 4.0

Education 4.0 is a revolutionary approach that transcends the limitations of traditional academic systems. It is a dynamic learning process that boasts three distinct features designed to equip learners with the skills necessary to thrive in the modern world (Puncreobutr, 2016):

- Regulating understanding 3R (Recalling, Relating, Refining)
- Triggering research 3I (Inquiring, Interacting, Interpreting)
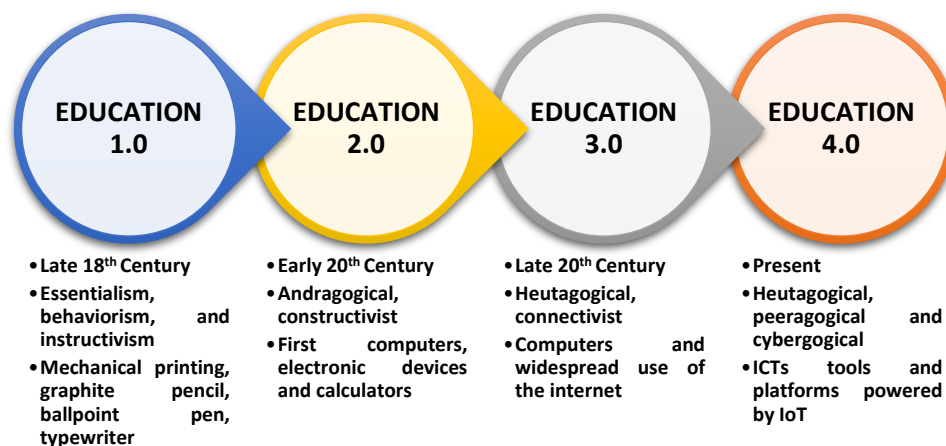- Being result-oriented 3P (Participating, Processing, Presenting)

Figure 1: Transition from Education 1.0 to Education 4.0
Source: Miranda et al. (2021)

Aziz Hussin (2018) analyses that Education 4.0 provides a comprehensive understanding of this new approach to learning. The three main components of this innovative system are clearly outlined, offering a detailed overview of the significant changes taking place in the field of education:

- **Smartness** arises from the increased capacity of information technology for fast and large-scale data processing and the utilisation of artificial intelligence.
- **Connectivity** refers to the interconnection of various objects and people through wired and wireless connections, local networks, and the Internet.

- **Real-time capabilities** brought about by advancements in sensor technology and data acquisition methods.

Gamification and Game-Based Learning

It has been recently discovered that the traditional approach of teacher-centred teaching is no longer beneficial for students for various reasons. One of the reasons is that students tend to memorise what the teacher says instead of thinking creatively. Another reason is that students cannot perform practical assessments through this approach, which hinders their ability to learn effectively (Jayasinghe & Dharmaratne, 2013). Therefore, the gamification approach incorporates game-like elements into technological, economic, cultural, and sociological processes, intentionally or as a natural evolution (Hamari, 2019). Game-based learning is the ongoing and purposeful use of games or video games in the classroom (Camacho-Sánchez et al., 2023; Jan et al. et al., 2015).

In today's world, technology has become an inextricable part of the daily lives of young people. However, there needs to be a more practical application of gamification in Additional Mathematics. Incorporating digital games into classrooms has emerged as an innovative teaching technique that keeps students engaged and helps them comprehend challenging mathematical concepts. Using gamification, teachers can design interactive and immersive math learning experiences that encourage students to participate actively and develop problem-solving and critical-thinking skills. Ultimately, this approach improves student academic outcomes (R.P. Dhiyaneshwari & Chinnasamy R.D, 2022).
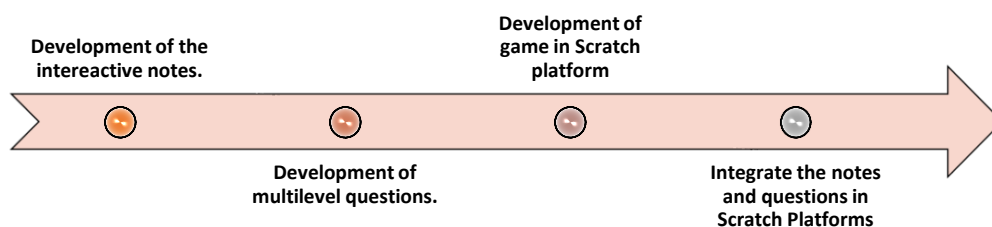
Methodology

Figure 2: Methodology

Figure 2 illustrates the methodology used in this research. The process starts with the development of interactive notes that are engaging, comprehensive, and user-friendly. These interactive notes incorporate multimedia elements such as videos, images, and audio to enhance user understanding and provide a stimulating learning experience. The next step in the process is the development of multilevel questions. These questions cater to various difficulty levels and encourage critical thinking skills. Diverse question formats aligned with learning objectives are created to challenge learners and test their understanding of the subject matter.

Then, game development on the Scratch platform supports hands-on learning and practical application. The Scratch interface is customised to align with educational content, allowing learners to navigate the platform easily and access the learning materials. Finally, the interactive notes and multilevel questions are integrated into the Scratch platform to ensure a seamless and cohesive user experience. The integrated system undergoes testing and

refinement to optimise functionality and enhance overall user satisfaction throughout the learning journey.

Results and Discussion

The Enigmatic Function Orb is an RPG game focusing on Function topics in Additional Mathematics. This innovative game seamlessly weaves the Malaysian KSSM Syllabus of Additional Mathematics with the Scratch platform, creating an interactive and immersive journey for players. At its core, the game features a wealth of educational resources, surpassing traditional textbooks with comprehensive notes that delve deeper into mathematical concepts. The integration of cloud saving ensures that players can seamlessly pick up their quest across devices, promoting continuous engagement. The captivating storyline is the game's backbone, guiding players through an enchanting narrative that unfolds alongside their mathematical exploration. The Enigmatic Function Orb is a revolutionary tool for learning Additonal Mathematics that offers a unique and captivating approach to education. It provides a wide range of questions designed to cater to the different skill levels of learners, from beginner to advanced. The games included in the program are designed to captivate and engage learners, making the learning experience more enjoyable and less tedious. By transcending the boundaries of traditional education, The Enigmatic Function Orb provides a multifaceted approach that promotes a deeper understanding and appreciation of mathematical concepts. The framework of the Enigmatic Function Orb is illustrated in Figure 3.
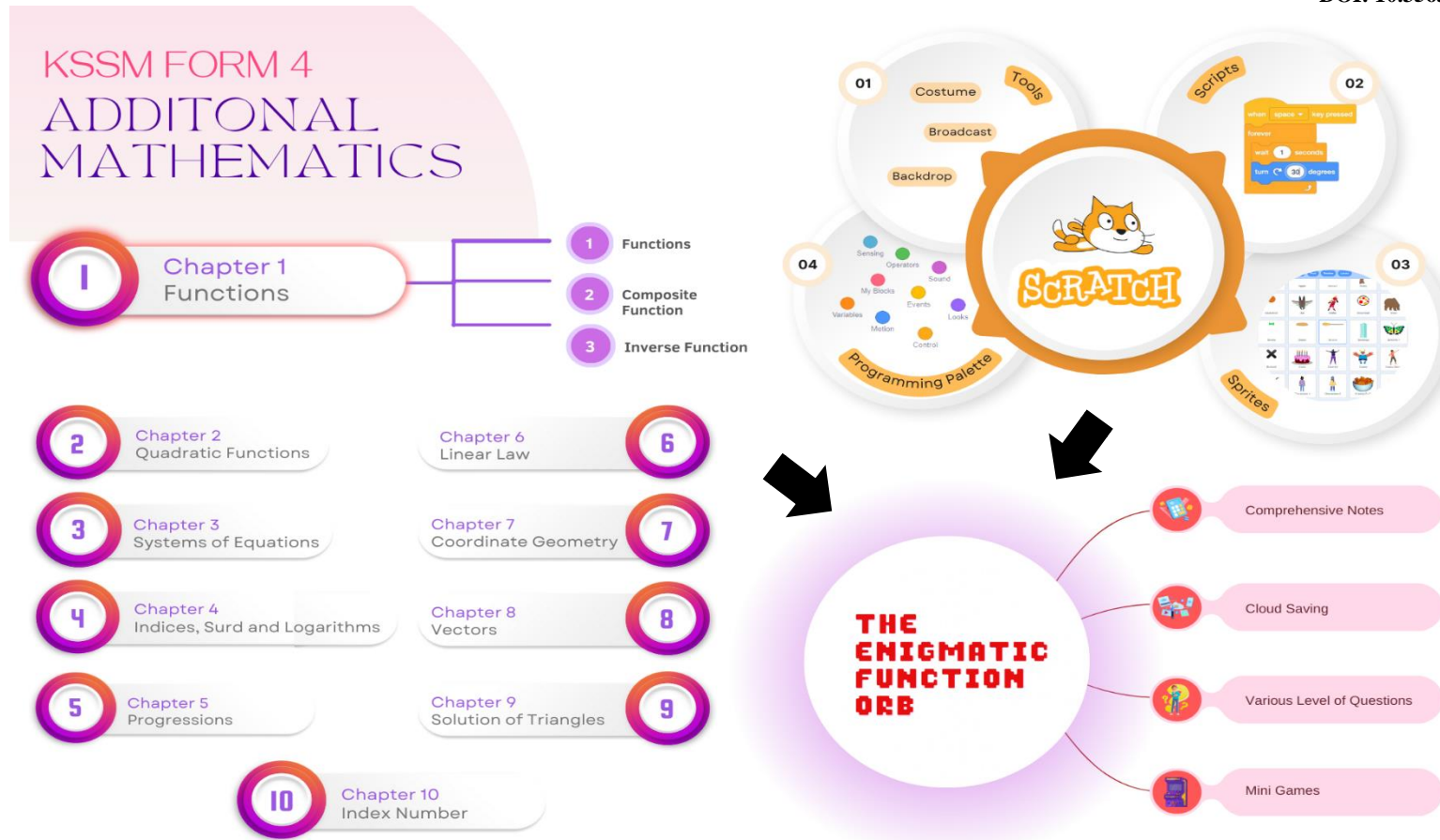
Figure 3: Framework of The Enigmatic Function Orb

Conclusions

The Enigmatic Function Orb is an innovative RPG game that integrates the Malaysian KSSM Syllabus with Scratch to offer an interactive and immersive educational experience. With its captivating storyline, the game guides players through various levels of questions and games, providing a multifaceted and engaging approach to learning mathematics. The game transcends the boundaries of traditional education, equipping students with the necessary skills and knowledge to pursue advanced studies and professional opportunities in science, technology, engineering, and mathematics (STEM). Future research should focus on how technology and education can use digital gaming to enhance educational understanding. While the effectiveness of gamification has been measured in terms of performance, observational studies are needed to gain more insight into how using digital gaming in educational settings can impact students' motivation and engagement levels.

Acknowledgements

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